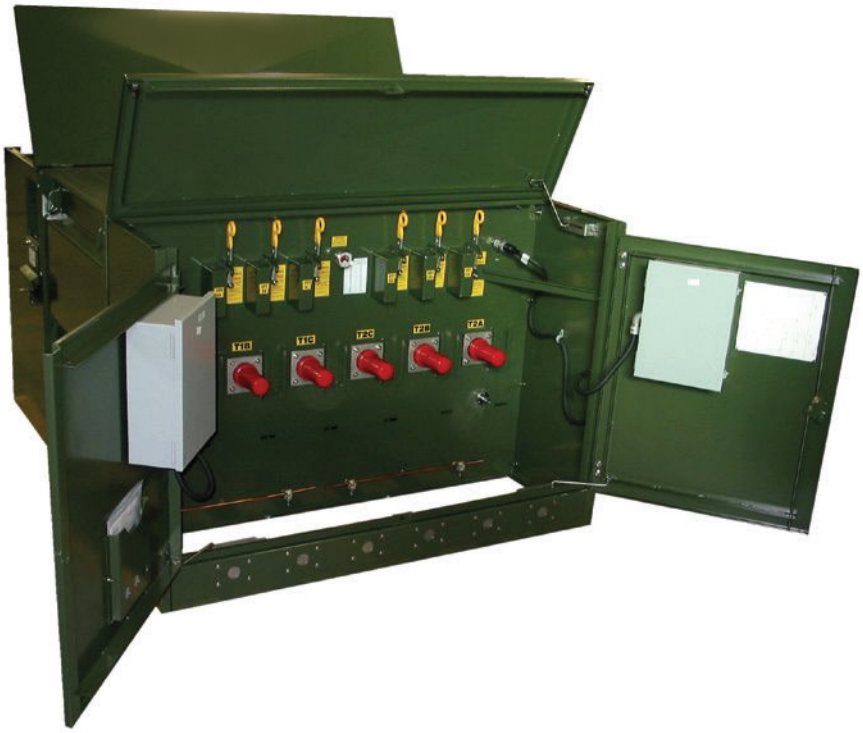
VFI underground distribution switchgear



General

Eaton Cooper Power™ series VFI underground distribution switchgear provides superior overcurrent protection through the use of proven, reliable vacuum fault interrupters. The resettable vacuum fault interrupter allows immediate service restoration, eliminating the added expense and downtime associated with stocking and replacing fuses.

Deadfront construction provides a higher level of safety for operating personnel. With the addition of visible-break switches, circuits can be isolated and grounded without disconnecting or moving terminations.

A sealed insulation system offers the further advantage of low-maintenance, and permits construction of a compact, low-profile unit that is less obtrusive than a comparable air-insulated design. Insulation options include the environmentally-preferred high-fire-point E200™ fluid and Envirotemp™ FR3™ fluid, as well as mineral oil and Sulfur Hexafluoride (SF_6) gas.

VFI switchgear is used for commercial/industrial and utility applications, and can be easily coordinated in the field without a PC, using field-selectable settings to meet distribution system protection requirements. Ratings of VFI switchgear are shown in Table 1.

Powering Business Worldwide

Table 1. Ratings for VFI Switchgear and Load-Break Switch*

Nominal Voltage		15 kV	15 kV	25 kV	35 kV
Maximum Design Voltage, kV		15.5	15.5	27.0	38.0
BIL, kV		95	95	125	150
1-minute Withstand Voltage (60 Hz), kV		35	35	60	70
Momentary Current, 10 cycles (sym.), kA		12.5	16.0	12.5	12.5
1-second Withstand Current (sym.), kA		12.5	16.0	12.5	12.5
Vacuum Fault Interrupter	Continuous Current, (max.), A	600**	600	600***	600
	Interrupting Current (sym./asym.), kA	12.5/20.0	16/25.8	12.5/20.0	12.5/20.0
	Making Current (sym.), kA	12.5	16.0	12.5	12.5
	Cable Charging Interrupting Current, A	10.0	10.0	25.0	40.0
Load-Break Switch	Continuous Current, (max), A	600	600	600	600
	Load Switching, A	600	600	600	600
	Fault Making (sym./asym.), kA	12.5/20.0	16/25.8	12.5/20.0	12.5/20.0

* Continuous and short-circuit currents may be limited by ratings of selected bushings.

** 900 A and 1200 A continuous-current ratings are also available on fluid units on ways without visible break.1200A requires stainless steel construction.

*** 900 A continuous-current ratings are also available on fluid units on ways without visible break.

Features and detailed description

VFI switchgear

Eaton's VFI underground distribution switchgear provides a simple, economical approach to protective requirements for 5, 15, 25, and 35 kV underground systems.

The deadfront construction of VFI switchgear improves safety for utility personnel and the general public. Inside, all terminations are covered with insulating rubber that is grounded. All internal parts are completely sealed in a steel tank to reduce maintenance and eliminate the problems of moisture, dirt, and wildlife.

This fluid-insulated, sealed design offers an added advantage: an unobtrusive, low-profile appearance.

VFI switchgear is versatile in its application. It is suited for commercial/industrial and utility requirements.

Single-sided compact style VFI switchgear units are ideal for areas where access is limited; such as next to a transformer, behind a building, against a wall, or in a vault. The VFI vault-style unit is suitable for indoor applications including commercial and industrial electrical equipment rooms. 5- and 6-way units are ideal for large retail complexes and campuses (military, university, industrial park) with multiple loads.

Figure 1. Compact single-sided units are available in vault and pad-mounted styles.

Figure 2. VFI switchgear 6-way unit.

For sustained reliability, VFI switchgear has 30 years of excellent field performance. The VFI switchgear's interrupting duty cycle is unmatched in the industry, providing a full 232 interruptions per IEEE Std C37.60™-2003 standard (see Table 2).

Tri-Phase control

The Tri-Phase electronic control provides a flexible solution for time-current-curve coordination. The Tri-Phase control offers over 100 minimum trip settings and an assortment of time-current curves. With standard instantaneous trip and optional ground trip and minimum response characteristics, the Tri-Phase control will satisfy system protection and coordination needs. A wide selection of TCCs and minimum trip settings make it easily adaptable to distribution systems.

Split two-sided design

Eaton offers a split two-sided design which allows for Visible Break windows and operating handles to be on one side and bushings on the other. This allows operators to safely access the operating handles and view the visible break window without exposure risk to the medium voltage bushings. Split two-sided units are available up to four ways in all kV classes.

Figure 3. Front – Operator Side

Figure 4. Back – Cable Side

Side operation

Side operation handles make it possible to operate the switch without opening the medium voltage cabinet. Side operation allows for manual operation only, and cannot be paired with motor operators. For more information regarding side operation, consult with factory.

Figure 5. Side Operating Handle

Edison™ Idea™ relays

Edison™ Idea™ relays allow enhanced functionality in protection and communication.

The IDEA Workbench™ embedded within the ProView™ software allow unsurpassed flexibility in customizing the relay protection and control functions through downloadable Custom Software Modules.

Depending on the relay selected, Edison Idea relays can provide protective functions such as overcurrent with or without ground detection, over/under voltages, reverse power, and negative sequence to name a few.

IMPORTANT

For applications requiring SF_6 insulated switchgear, contact your Eaton representative when selecting a relay/controller that has metering and protective elements requiring potential transformers.

Advanced metering and analytics are also available which are critical to providing Distribution Automation capability.

Single- or three-phase tripping

Most commercial loads consist of large three-phase transformers. Many transformers are protected with single-phase fuses. Typically, only one of the fuses will open during an overcurrent condition. This "single-phases" three-phase commercial loads, and may cause damage to three-phase motors and other equipment. VFI switchgear solves this problem by providing three-phase ganged tripping. An overcurrent on any phase automatically opens all three phases simultaneously clearing faults within 2 cycles.

VFI switchgear can also be specified with single-phase trip, to provide individual phase protection for single-phase residential applications.

VFI switchgear can also serve as a vacuum loadbreak switch. Tap switching has traditionally been accomplished by pulling loadbreak elbows. With VFI switchgear, the tap can be switched with a simple push-pull of the operating handle.

Table 2. Interrupting Duty Cycle

Minimum Full Life Fault Interrupting Duty Cycle per IEEE Std C37.60™-2003 standard (2 duty cycles)		Number of Operations
Percent of Interrupting Current Rating:	15-20%	88
	45-55%	112
	90-100%	32
Total		232

Vacuum loadbreak switch

Source switching is accomplished by three-phase, vacuum loadbreak switches. The ratings for the vacuum switches are in Table 1.

Visible-break switch

Visible-break switches are available in two versions—a two-position switch (closed/open) and a three-position switch, (closed/open/ground). Visible-break is accomplished by a separate switch operated from the side of the unit—away from the high voltage compartment. This switch is mechanically interlocked such that the vacuum load-break switch or the vacuum fault interrupter mechanism first interrupts the current and then the visible-break switch may be operated. The visible-break switch is rated 600 A continuous current and has a making current rating up to 16 kA (sym). The ground position allows the cables to be grounded without disconnecting or moving the terminations. The switch contact positions are visible via a large viewing window above the associated bushings. Only VFI switchgear with liquid dielectric may be equipped with a visible-break feature.

Types of insulation

Eaton offers underground distribution switchgear with the widest availability of dielectric media in the industry. Fire-resistant E200 fluid and Envirotemp™ FR3™ fluid, as well as commonly used mineral oil and SF_6 gas, are offered as insulation media for VFI switchgear.

E200 fluid

E200 fluid is fire-resistant biodegradable, polyol ester-based, non-toxic low viscosity fluid with excellent dielectric, thermal and physical properties. The low viscosity characteristic allows it to be used in VFI switchgear down to -30°C. Its fire point is greater than 300°C (572°F), a requirement for less flammable fluids.

The performance of the switchgear equipment containing E200 fluid is further enhanced by the fluid's other important properties:

- Excellent thermal properties
- High dielectric strength
- Oxidation stability
- Clear bright appearance

Envirotemp™ FR3™ fluid

Envirotemp™ FR3™ fluid is formulated from edible vegetable oils and food grade performance enhancing additives. It does not contain any petroleum, halogens, silicones, or any other questionable material. It quickly and thoroughly biodegrades in both soil and aquatic environments. The fluid tested non-toxic in aquatic toxicity tests.

Mineral oil

Mineral oil is a petroleum-based, time-proven insulation and has reliable electrical insulating properties.

SF_6

SF_6 is non-flammable, odorless, colorless gas that requires a gas-tight design and gas monitoring and handling systems.

Table 3. Available Dielectric Media–Minimum Application Limits

E200 Fluid	-30°C to +55°C*
Envirotemp™ FR3™ Fluid	0°C to +55°C*
Mineral Oil	-30°C to +55°C*
SF_6 Gas	-30°C to +55°C*

* +55°C rating includes 15°C solar temperature rise.

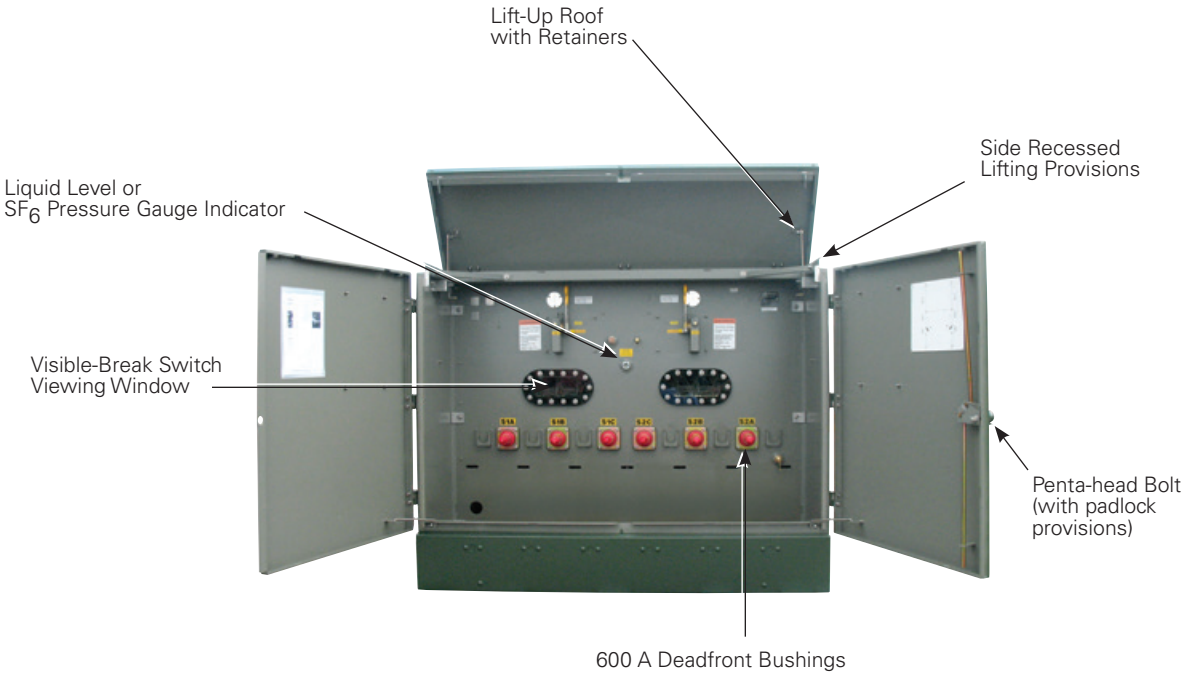


Figure 6. VFI switchgear source-side switch components (some optional components shown).

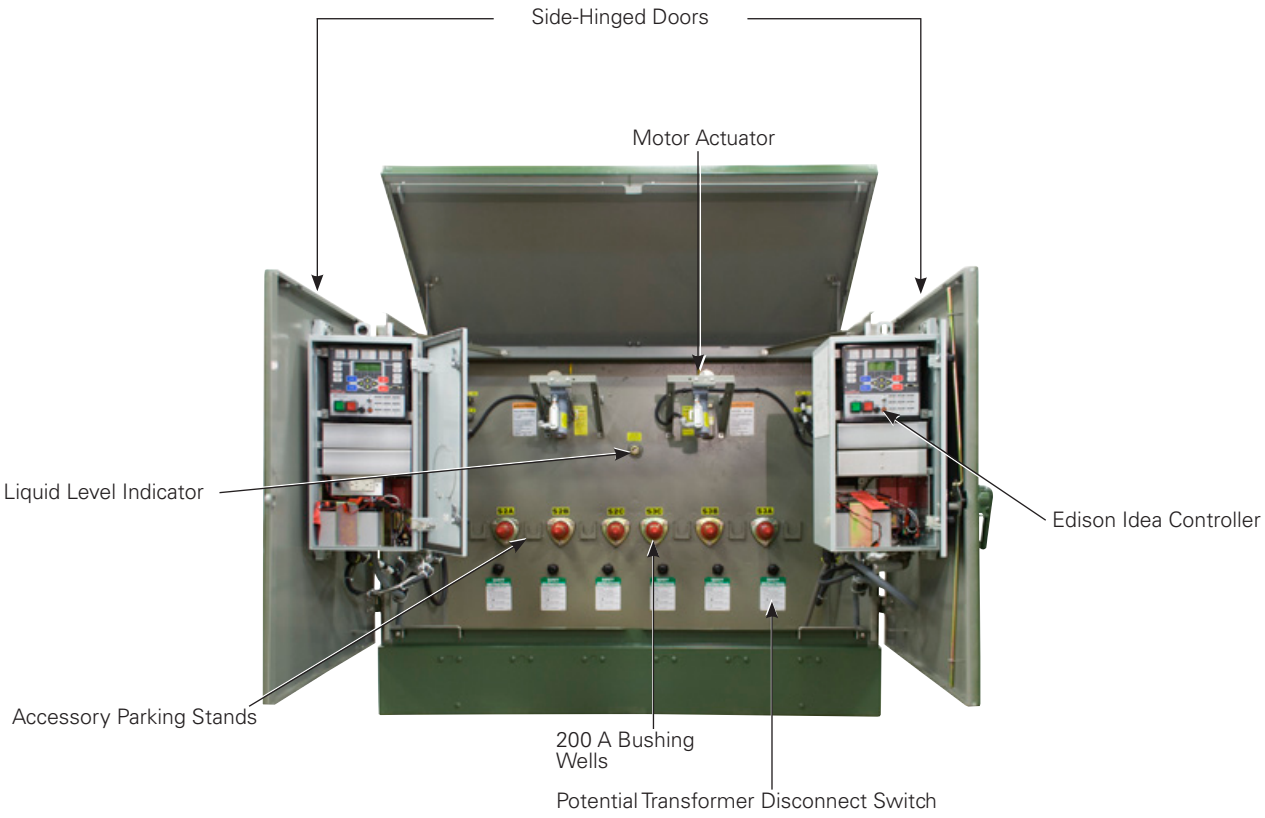


Figure 7. VFI switchgear tap-side components (some optional components shown).

Low Profile sealed construction

VFI switchgear features a low-profile cabinet design, with sealed tank construction. This means that VFI switchgear can be used in locations where air-insulated switchgear cannot, such as flood areas or high-contaminant industrial sites. It is resistant to attacks from dust, ice, vegetation, and wildlife.

Steel construction

Mild or stainless steel (304L & 316L) construction including tank, cable compartments, and controls.

Mild Steel construction meets requirements of Standard for Pad-Mounted Equipment–Enclosure Integrity IEEE Std C57.12.8™-2005 and Stainless Steel meets IEEE Std C57.12.9™-2005 Standard for Coastal Environments.

Trip-free operation

The vacuum fault interrupter mechanism can be quickly and easily reset manually by pulling the handle to the "reset" position and then moving it to the closed position. However, if a fault is present when the vacuum fault interrupter mechanism is closed, the trip-free feature will prevent the mechanism from being held in the closed position and it will clear the circuit fault.

UL® Listed and Labeled

VFI switchgear and a number of its features can be UL® listed and labeled to meet customer requirements as necessary. These features are available for the family of VFI switchgear products as follows:

- 15 kV and 25 kV voltage ratings
- 600 A continuous current rating
- 12.5 kA symmetrical interrupting rating
- Fluid Dielectrics (mineral oil, E200 and Envirotemp™ FR3™ fluids)
- Visible-break switch (two- and three-position)
- Mild and stainless steel construction
- Tri-phase and TPG control
- All standard combinations of load switches and fault interrupters

Low maintenance

Both load and fault interruption take place within the sealed vacuum fault interrupter with no arcing by-products to contaminate the insulating medium. Advanced technology vacuum fault interrupters are reliable, have long life and require no maintenance. Eaton's patented design reduces the arc energy—resulting in far less contact erosion and the longest life of any vacuum fault interrupter in the industry. Since there are no expulsion fuses or switching by-products to contaminate the insulation medium, maintenance intervals are greatly increased.

Advanced protection relays and tri-phase controls

Eaton's Cooper Power series Edison™ Idea™ relay, Schweitzer Engineering Laboratories™, and Tri-Phase/TPG controls makes use of internally mounted current transformers (CT), one on each phase, to monitor line current. If the current in any phase exceeds the minimum trip level setting, the control begins a user selectable time-current-curve (TCC) delay sequence.

At the completion of the programmed TCC delay, a signal is issued to trip the vacuum fault interrupter mechanism.

CT circuits

The Tri-Phase control is self-powered by the line current. It requires no external voltage supply or battery backup. Since the Tri-Phase control is powered by the sensing 1000:1A CT circuits, it is not affected by system voltage conditions. The standard internal 1000:1A CT accuracy is approximately 5%.

Edison Idea and Schweitzer Engineering Laboratories™ relays also support internal CT ratios of 600:5A (C100 Class) and 200:1A (Solar). Relays require a 120 Vac power source to power their internal battery source. The standard battery provided is an 13 Ah. 18 Ah batteries are an option.

Figure 8. TPG control with SCADA shown.

Tri-Phase control settings

The minimum-trip setting for each phase is selectable. This permits convenient field configuration of the Tri-Phase control, to meet specific application requirements.

The control features an assortment of field replaceable TCC modules, each provides a fixed time-current-curve characteristic. The variety of modules available provides coordination flexibility between the Tri-Phase control and other protective equipment. See Literature TC285001EN for Tri-Phase & TPG TCC Curves.

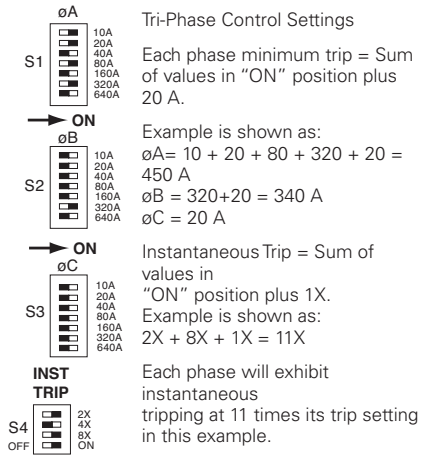


Figure 9. Tri-Phase control settings.

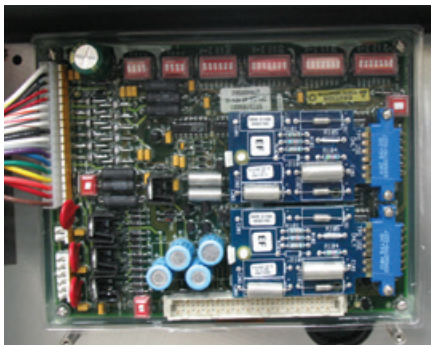


Figure 10. Typical Tri-Phase with ground trip control (TPG) module.

Tri-Phase control normal load

At normal system current, the Tri-Phase control is effectively dormant. Load current is continuously being compared to the selected minimum-trip settings, but the TCC and trip circuits are not activated.

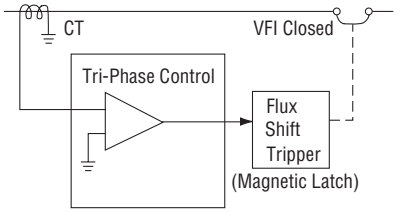


Figure 11. Normal load diagram.

Tri-Phase control overcurrent protection

The TCC circuit is activated when current above the pre-selected minimum trip value is sensed. Once activated, the TCC circuit uses the magnitude of the overcurrent to establish a time delay. At the completion of the delay, the trip circuit pulses the Flux Shift Tripper, which causes it to trip open the vacuum fault interrupter mechanism.

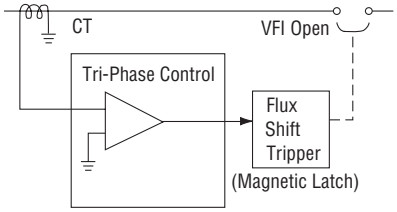
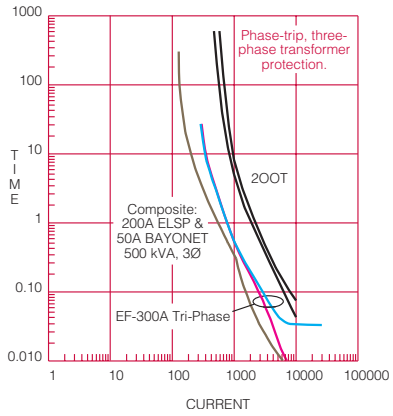


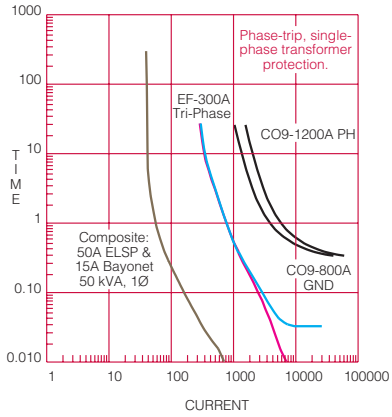
Figure 12. Tri-Phase control overcurrent protection diagram.

Tri-Phase control coordination flexibility

The E time-current curve has long been an industry standard for underground distribution switchgear fusing. However, when several protective devices are present on the same line, it can become difficult to obtain proper system coordination. The Tri-Phase control, with the EF TCC installed, combines classic switchgear protection with state-of-the-art vacuum fault interrupter technology. The Tri-Phase control eliminates the problems normally associated with fuses, but preserves and extends the familiar E-shaped curve to higher currents.



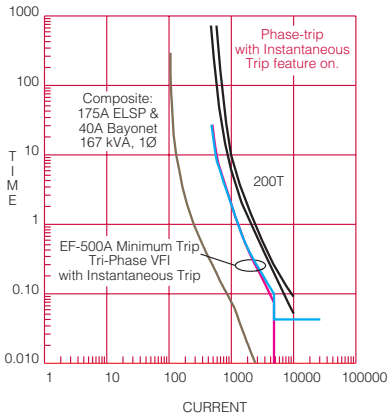
Coordination and application of the Tri-Phase control is identical to fuse application, but with the benefit of a greatly expanded offering of trip ratings and timing curves. In the following example, the EF TCC provides ideal coordination when protecting single-phase distribution transformer loop schemes. The cable can be protected to its rated load with sufficient margin between the EF and the substation breaker.



Tri-Phase control instantaneous trip

Instantaneous trip, a standard feature of the Tri-Phase control, extends the range of coordination with upstream devices, at higher fault levels. A switch on the control circuit board enables the instantaneous trip feature and programs a multiplier that is applied to the standard minimum trip setting. When current above the predetermined fault level is sensed, the instantaneous trip feature causes the control to bypass the normal TCC delay and trip immediately; thus eliminating any intentional time delay. For faults below this actuation level, the control operates according to its normal settings.

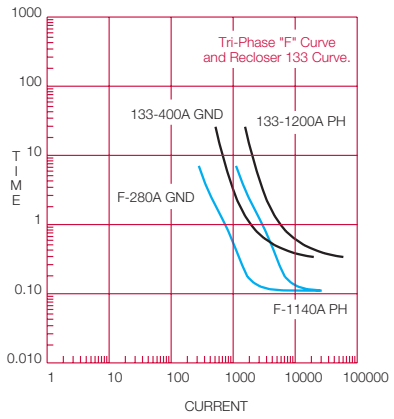
In the example, the EF curve coordinates well with the transformer fusing, although instantaneous trip is required to extend coordination with the upstream T-Link.



Optional Tri-Phase with ground trip control (TPG)

The optional TPG control operates under the same algorithm as the standard Tri-Phase control for phase protection. In addition, the TPG control has a separate zero-sequence circuit and settings for ground protection. Settings for ground trip vary from 10 A to 640 A in 10 A increments, and are field selectable by the user.

In some applications, such as a switchgear tap that feeds both underground and overhead feeders, the TPG control is necessary. As shown below, the F curve achieves coordination with both the phase and ground settings of the upline recloser.

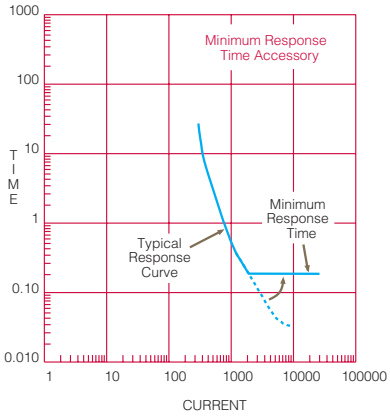


Tri-Phase control accessories

Minimum response time

The minimum response time accessory is used to achieve coordination between in-line protective interrupting devices, located where fault-level currents would normally cause simultaneous tripping.

The accessory inhibits tripping until a predetermined minimum time has elapsed; available minimum response times are adjustable at 0.050, 0.100, 0.145, 0.205, 0.260, 0.335, 0.405, 0.495, or 0.580 seconds. Refer to the example below.



Minimum trip multiplier

The minimum trip multiplier accessory allows the user to increase the programmed minimum trip setting, to a predetermined alternate setting, by operating a toggle switch. Typical applications for an alternate minimum trip settings include: preplanned or emergency load transfers, maintenance, or other routine switching conditions where line or feeder load temporarily exceeds the normally anticipated levels.

TPG ground trip control

The TPG control includes phase and ground-fault protection for systems where increased sensitivity is required. If a ground-fault is detected, the control will begin a time-current curve delay sequence. At the completion of the programmed delay, a signal is issued to trip the vacuum fault interrupter mechanism.

Since the ground-fault curves are more sensitive than the phase curves, they can offer a distinct advantage in those special applications where increased sensitivity and speed in overcurrent protection are required. As a result, coordination with upstream devices (i.e., electronic reclosers) can be obtained where TCC coordination is difficult.

TPG SCADA accessory

VFI switchgear, when ordered with the TPG control, may also be supplied with an optional SCADA accessory. The SCADA accessory provides the user with remote functionality, along with Status and Fault indicators, for each TPG-controlled vacuum fault interrupter mechanism and includes battery backup. For additional information, refer to *Service Bulletin S285-75-1, Tri-Phase, TPG, and TPG with SCADA Electronic Control Installation and Operation Instructions*.

Edison Idea relays

IMPORTANT

For applications requiring SF_6 insulated switchgear, contact your Eaton representative when selecting a relay/controller that has metering and protective elements requiring potential transformers.

Edison Idea relays offer advanced protection and control options for the most demanding applications. Three different relays are available:

iDP-210 relay-provides multi-function protection elements for one source or tap.

iTAP-265 relay-provides overcurrent protection for two three-phase taps.

iTAP-260 relay-provides overcurrent protection for two three-phase taps with independent settings for each phase. Each phase can be independently tripped.

Edison Idea relays meet all applicable relay standards, Including IEEE Std C37.90™-2005 and IEEE Std 1547™-2003 standards.

All relays include the following features and functions:

- Incipient Cable Splice Fault (ICSF) Detector
- Sequence of Event recorder with capacity to store the most recent 250 events in non-volatile memory
- Oscillography for fault analysis
- Programmable Data Profiler to record any combination of the available metering data
- Metering – instantaneous current, voltage, power factor, power, energy, demand, and harmonics
- Communications protocols shall include DNP3 via serial and TCP/IP, and Modbus via serial
- Graphical programming environment for custom logic and communication point maps
- Virtual Test Set™ for testing relay settings without the need for an external test set
- Integral breaker Interface panel, including illuminated Trip and Close pushbuttons, Close Inhibit switch, and close circuit disable link
- Twenty-five front panel LED targets to indicate relay status

iDP-210 feeder protection relay

The iDP-210 is a full-featured relay suitable for a variety of protection applications, including source protection, feeder protection, and distributed generation inter-ties. Integral motor control logic for the VFI switchgear operator is included as standard. The protective elements in the iDP-210 relay are listed below.

- Phase instantaneous, definite time, and inverse time overcurrent (50/51)
- Ground instantaneous, definite time, and inverse time overcurrent (50N/51N)
- Negative Sequence instantaneous, definite time, and inverse time overcurrent (50Q/51Q)
- Directional phase, ground, and negative sequence elements (67P, 67N, 67Q)
- Reverse Power (32)
- Voltage elements: Definite time undervoltage (27), Definite time overvoltage (59), Negative sequence, and zero sequence over voltage (59N)

Figure 13. The iDP-210 is a member of Eaton's Cooper Power series Edison Idea line of protective relays.

- Frequency elements: definite time underfrequency (81U) and definite time overfrequency (81O)
- Sync-check (25)
- Highly configurable four-shot recloser (79)
- Breaker failure (BF52)

iTAP-265 dual overcurrent relay

The iTAP-265 relay provides overcurrent protection for two three-phase taps. Additional functionality can be programmed in the IDEA Workbench feature of ProView™ software.

- Phase instantaneous/definite time, and inverse time overcurrent (50/51) for each three-phase tap
- Ground instantaneous/definite time, and inverse time overcurrent (50N/51N) for each three-phase tap

iTAP-260 dual overcurrent relay

The iTAP-260 relay provides overcurrent protection for two tap with independent settings for each phase Additional functionality can be programmed in the IDEA Workbench feature of ProView software.

- Phase instantaneous/definite time, and inverse time overcurrent (50/51) for each phase. Six elements total
- Ground instantaneous/definite time, and inverse time overcurrent (50N/51N) for each phase. Two elements total.

iST control

iST relay

The iST relay is used with VFI for automatic source transfer (within eight seconds) using external motor operators. For highspeed (6 cycle) source transfer applications, refer to Eaton PST catalog CA285001EN.

The iST relay provides automatic transfer between two sources and provides advanced metering, control, communications and event analysis tools.

The iST relays use ProView® application software for PCs running the Microsoft® Windows® operating system. The Idea Workbench™ feature of ProView permits the user to add additional functionality.

To address the needs of automation, Energy Management Systems (EMS), and SCADA systems, the iST family of relays provide advanced power quality, load (tap) metering, control and communications capabilities.

Transfer logic

The comprehensive transfer logic includes the following features: Five source preference selects:

- Source 1 preferred; Normal restoration
- Source 1 preferred; Hold on alternate
- Source 2 preferred; Normal restoration
- Source 2 preferred; Hold on alternate
- No Source Preference

Normal restorations can be either Non-parallel with an adjustable time delay, or Parallel with sync-check.

The Parallel with Sync Check Restoration Mode supervises source closing for both automatic and manual operations. The Sync Check function compares the phase rotation, voltage magnitude, phase angle and frequency of both sources. Paralleling of the sources is permitted only when all parameters are within the customer configurable threshold. In automatic mode, it permits closing the preferred source prior to opening the alternate source to achieve a "blinkless" transfer.

In manual mode, the Sync Check function prevents accidental paralleling of non-synchronous sources. If parallel restoration is not enable, both source switches cannot be closed in manual mode from the relay panel.

The alternate source can be either a utility line or a generator. Settings for generator startup time, standby time and shutdown time are included.

There are seven independent parameters for Source Health. Each has a settable threshold and time delay.

Figure 14. iST relay front plate.

Any combination can be enabled to declare an unhealthy source:

- Two levels of phase-ground undervoltage (27)
- Positive sequence undervoltage (27P)
- Two levels of underfrequency (81U)
- Two levels of overfrequency (810)

Four independent parameters declare Source Restoration. Any combination can be enabled to declare a restored source.

- Minimum phase-ground voltage (59)
- Minimum positive sequence voltage (59P)
- Minimum frequency (81U)
- Maximum frequency (81O)

Overcurrent protection

The iST-621 relay offers overcurrent protection of the single load, and separate inverse curves for phase and residual CLPU overcurrent elements to minimize nuisance trips. The TCC selection IEEE™ and IEC curves, industry standard recloser curves, 106 through 165, plus five commonly used fuse curves.

A fault block function is included to enable or disable automatic transfer during an overcurrent (OC) event.

When enabled in the iST-621 single feeder application, fault block prevents an automatic transfer while the OC element is picked up. When an OC trip occurs, the iST-621 relay is switched to manual mode to prevent automatic operations until the relay is reset.

Metering

- Instantaneous voltage and frequency of each source and feeder current
- Current, Watts, VARS and power factor of each feeder
- Demand metering (current and four quadrant power) of each feeder
- Energy metering (four quadrant) of the feeder
- Harmonics metering through the 15th harmonic including THD for all voltage and all current channels

iST relays automatically use the PTs of the connected source for all power, energy and other voltage-related metering.

Customize with the IDEA Workbench

Edison Idea relays are fully functional relays, ready to use right out of the box. However, there are applications where custom control logic, or custom functions need to be added to the relay. The IDEA Workbench is a revolutionary graphical software programming environment which permits the user to customize the relays.

- Add new features or protective functions by means of IDEA Workbench Custom Modules. These operate in the same fashion as the plug-ins for popular internet browsers. Your investment in the relay is protected as future needs and developments may be addressed through new Custom Modules.
- Create custom control and protection logic using over 400 programming signals and tools, all selectable from drag-off Toolboxes. Logic created suing these tools can then be saved as Custom Modules to be reused or shared with associates.
- Monitor and control practically every aspect of the relay's operation
- Create custom metering and measurement quantities
- Create custom sequence of event records
- Configure communication protocols to match existing SCADA system mappings

The IDEA Workbench offers the user the ability to rapidly and accurately create customizations by working the way the engineer thinks, by using logic diagram and flowchart construction methods. No equation-based or command-based logic programming is required.

The IDEA Workbench also addresses some of the more difficult questions associated with custom relay programming, namely:

Clarity: Compared to that offered by equation and command based programming techniques, graphical programming results in customizations whose operation is intuitive.

Testing: ProView provides a Virtual Test Set (VTS), which can be used to test the developed logic with realistic fault signals. During test, the logic diagrams become "live" showing the state of all variables, logic gates, contacts, counters, etc. To avoid any question of how the custom logic interacts with the relay itself, the VTS environment models the entire relay in addition to the custom programming. Unlike other programming environments, the IDEA Workbench does not require the user to have an actual relay or relay test set on hand to verify the proper operation of the programmed logic.

Documentation: Notes regarding how the custom logic operates may be embedded within the IDEA Workbench. This improves the ability of others to quickly understand how the logic is designed to work. Links to external files may also be embedded in the IDEA Workbench, providing fast access to larger documents stored on company's network servers.

Portability: If the original data files are lost, the entire IDEA Workbench may be uploaded from the relay, complete with logic diagrams, embedded notes and external reference links.

Event records and analysis tools

The iDP-210 relay shares the same event records and analysis tools as all Edison Idea relays. The Edison Idea allows for the display of event records in a variety of formats including waveforms (oscillography), magnitude plots, phasor diagrams, symmetrical component diagrams and more. ProView, the software for the Edison Idea relay, also provides a unique Application Diagram View that provides a one-screen view of everything that is going on in the relay. Many of these event views are also available in On-Line View mode, where it is possible to monitor the status of the relay in real-time, including phasor diagrams, which is ideal for verifying CT phasing during commissioning. The iDP-210 relay also includes distance to fault indication.

Relay Replay™

To evaluate the effect different settings would have on the relay, the Relay Replay™ feature of the Edison Idea software allows the user to make any number of setting changes and replay an existing event using these new settings without the need for an actual relay or expensive test equipment. The operation of every aspect of the relay's performance, from which elements pick-up, the response time of those elements that do and the operation of any custom programming made via the IDEA Workbench can be observed. This tool provides unprecedented "what-if" analysis capabilities.

Virtual Test Set (VTS)

To evaluate settings against any arbitrary fault, the Edison Idea software permits the user to create a virtual event record through use of the software's VTS feature. The VTS allows complete control over:

- Pre-fault and post-fault voltage and current levels
- Selection of phase-ground, phase-phase, phase-phase-ground and three-phase fault types
- Fault duration
- Selection of system and fault impedances
- Selection of DC time constant
- Control over fault dynamics to verify reclosing sequences and sequence coordination
- Control of frequency change, rate of change, and acceleration during faults
- Control over simulated breaker open and close times
- Voltage and current parameters derived from a built-in power system model or entered manually.

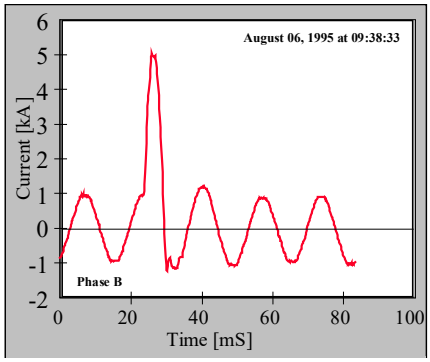


Figure 15. Typical self-clearing fault detected by the iDP-210 relay ICSF algorithm.

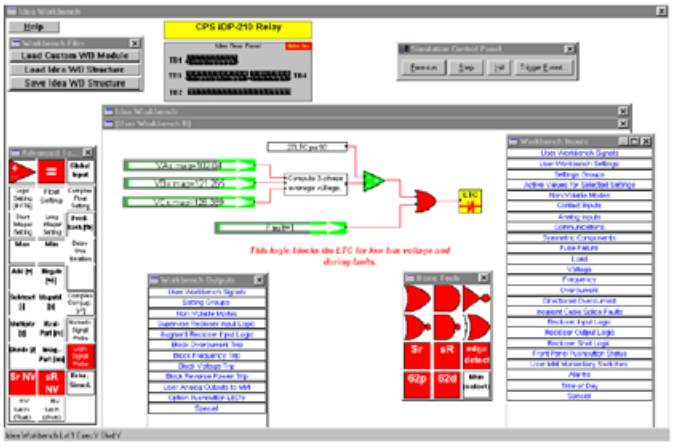


Figure 16. The IDEA Workbench graphical customization environment.

Communications

Both Modbus RTU and DNP 3.0 communication protocols are included with the iDP-210 relay. A Communications Workbench™ provides the user the ability to customize communication maps, add or delete information, add control points, and even create new signals to be brought out through communications. The iDP-210 relay features two RS-232 auto-baud (57600 kbps max) communication ports and one port configurable for RS-485, serial fiber optic, and various Ethernet options (RJ-45, multi-mode fiber, single-mode fiber). Contact your Eaton representative for availability of other communication protocols.

Incipient cable splice fault detector (ICSF)

One of the most common causes of buried cable failure is from moisture ingress to buried cable splices. When sufficient water accumulates in the splice, a line-to-ground fault briefly occurs. The fault is cleared as the water is suddenly converted in to steam. Over time, the insulation is damaged and the cable splice eventually fails. The iDP-210 relay contains an algorithm to recognize the unique waveform characteristics of these self-clearing faults. See Figure 15. By counting how often these events occur over a moving time window, the iDP-210 relays are able to give advance notice of pending cable splice failures. This permits cable maintenance to be scheduled rather than addressed on an emergency basis.

Overcurrent protection

The iDP-210 relay offers inverse time, definite time (2 levels) and instantaneous elements for phase, residual and negative sequence overcurrent protection. An additional definite time ground overcurrent element is provided for a separate zero-sequence flux summing CT. This fourth current channel input may also be ordered in a sensitive earth fault version which may be set as low as 0.005 A secondary. Each overcurrent element may be independently selected to be non-directional, forward- or reverse-directional. Inverse time elements may be set for disk-like or instantaneous reset characteristics. Complete fuse-fail detection logic is also included to selectively non-directionalize or disable directional elements during loss of bus potential.

Eaton Smart VFI switchgear available with Schweitzer Engineering Laboratories SEL-751

Overcurrent protection

Protect radial and looped distribution circuit with comprehensive protection capabilities, including phase and ground overcurrent, directional overcurrent, reverse power, over/undervoltage and over/under frequency.

Automation and control

One SEL-751 relay per three-phase feeder provides protection, automation and control capabilities in an integrated package; includes integrated motor control and battery backup power, as well as built-in metering functions.

Event analysis

Detailed event records available.

Programming

User-friendly programming template for quick and easy setup using ACSELERATOR QuickSet® SEL-5030 Software for relay settings and logic programming and to simplify development of SELOGIC control equations.

- Power supply: 24-48 Vdc (SELect PSIO2DI/3DO); 24 VDC/VAC digital input
- Front panel: 8 pushbutton controls, 2x16 character LCD display
- Processor board: Single 10/100 Base-T Ethernet, EIA-232 rear with single multimode ST fiber-optic serial port rear
- Protocols: Standard plus DNP3 plus IEC 60870-5-103 plus IEC 61850

Figure 17. Schweitzer Engineering Laboratories Multiple SEL-751's integrated in exterior cabinet.

Figure 18. Schweitzer Engineering Laboratories SEL-751 integrated in internal cabinet.

SEL-751 Relay elements

User-friendly programming template for quick and easy setup using ACSELERATOR QuickSet™ SEL-5030 Software for relay settings and logic programming and to simplify development of SELOGIC control equations.

- Synchronism Check Device (ANSI Device 25 *optional)
- Under-Voltage Elements (ANSI Device 27)
- Directional Power (ANSI Device 32)
- IEC Cable/Line/Machine Thermal Overload (ANSI Device 49)
- Phase Instantaneous, Definite Time and Inverse Time Overcurrent (ANSI Device 50P/51P)
- Ground Instantaneous, Definite Time and Inverse Time Overcurrent (ANSI Device 50G/51G)
- Neg. Seq. Instantaneous, Definite Time and Inverse Time Overcurrent (ANSI Device 50Q/51Q)
- Neutral Instantaneous, Definite Time and Inverse Time Overcurrent (ANSI Device 50N/51N)
- Power Factor (ANSI Device 55)
- Over-Voltage (ANSI Device 59); Phase, Ground and Neg. Seq. Over-Voltage (ANSI Device 59P, 59G and 59Q)
- Loss of Potential/Voltage and Current Balance (ANSI Device 60)
- Directional Neutral, Phase, Ground and Neg. Seq. Overcurrent (ANSI Device 67N, 67P, 67G and 67Q)
- Auto-reclosing (ANSI Device 79 *optional)
- Over Frequency, Under Frequency and Rate-of-Change Frequency (ANSI Device 81O, 81U and 81R)

Eaton Smart VFI switchgear available with SEL-501 overcurrent relays

Eaton combines field-proven apparatus and controls by integrating Cooper Power series VFI underground distribution switchgear with Schweitzer Engineering Laboratories (SEL) distribution protection relays to provide a robust innovative, fully integrated Smart VFI switchgear package.

Overcurrent protection and control

One SEL-501 relay protects two three-phase feeders with overcurrent protection and control capabilities in an integrated package. Includes battery backup power, as well as built-in metering functions.

Event analysis

Detailed even records available

Communications and metering

Integrate the SEL-501 relay into serial or Ethernet based communications with IEC 61850, IEC 60870-5-103, Mirrored Bits communications, Modbus and DNP3 protocols. Metering of instantaneous, demand and peak demand currents.

Programming

User friendly programming template for quick and easy setup using ACSELERATOR QuickSet® SEL-5030 Software for relay settings and logic programming and to simplify development of SELOGIC control equations.

Figure 19. Schweitzer Engineering Laboratories SEL-501 integrated in cabinet.

Figure 20. Schweitzer Engineering Laboratories SEL-501 relay front panel.

Included options

- Power supply/control input voltage: 24 Vdc / 24 Vdc
- Communications port: EIA-232
- Protocols: Standard plus Modbus

Feeder protection

Protect radial and looped distribution circuit with comprehensive protection capabilities, including phase and ground overcurrent, directional overcurrent, reverse power, over/under voltage and over/under frequency.

SEL-501 dual-overcurrent relay elements

- Overcurrent Protection for Two Three-Phase Feeders
- Instantaneous Overcurrent Relay (ANSI Device 50H)
- Neutral Instantaneous Overcurrent Relay (ANSI Device 50NH)
- Definite-Time Phase Overcurrent Element (ANSI Device 50PT)
- Definite-Time Negative Sequence Overcurrent Element (ANSI Device 50QT)
- Definite-Time Neutral Overcurrent Element (ANSI Device 50NT)
- Inverse-Time Phase Overcurrent Element (ANSI Device 51PT)
- Inverse-Time Negative Sequence Overcurrent Element (ANSI Device 51QT)
- Inverse-Time Neutral Overcurrent Element (ANSI Device 51NT)

Eaton Smart VFI switchgear available with Schweitzer Engineering Laboratories SEL-451 relay

The SEL-451 provides a protection, automation and control systems with multiple instantaneous, time-overcurrent and directional elements combined with SELogic control equations, AST detects high-impedance faults. Low Energy Analog ILEA) voltage inputs help protect pam-mounted switchgear.

Source transfer

- Transfer speeds of 5-8 seconds when used with Eaton's VFI switchgear
- When used with Eaton's PST switchgear, auto source transfer speed is 6 cycles or less

See catalog CA285001EN for more information regarding PST switchgear.

Customized programming

Create your own custom application using SELogic control equations.

Figure 21. Schweitzer Engineering Laboratories SEL-451 integrated in exterior cabinet

Figure 22. Schweitzer Engineering Laboratories SEL-451 relay front panel

Production elements

- Synchronization check device (ANSI Device 25 optional)
- Under-voltage elements (ANSI Device 27)
- Directional power (ANSI Device 32)
- Dual breaker overcurrent (ANSI Device 50B)
- Overcurrent (ANSI Device 50)
- Over-voltage (ANSI Device 59)
- Directional overcurrent (ANSI Device 79)
- Auto-reclosing (ANSI Device 79)
- Over frequency (ANSI Device 81O, 81U)

- **Additional functions**
- Access security (serial, Ethernet)
- Best choice ground
- Breaker wear monitor
- Event reports
- Harmonic blocking
- High-impedance fault detection Arc Sense™ Technology (AST)
- Operator interface
- Load encroachment
- Fault locator
- High-accuracy metering
- Synchrophasors
- Station battery monitor
- Sequential events recorder
- Time-domain link remote data acquisition

Eaton's Smart VFI switchgear available with Schweitzer Engineering Laboratories SEL-487e transformer protection relay

Differential protection

The SEL-487e relay provides differential protection and three restricted earth fault elements which minimize damage and expensive repairs to transformers. The relay provides current differential protection for up to five 3-phase terminals for transformers located at power plants, transmission substations, distribution substations and industrial plants

Overcurrent protection

The SEL-487e relay eliminates the need to change settings groups to accommodate different time-delay and pickup levels in the selectable time-overcurrent elements, allowing the pickup and time-delay settings to change instantly, without the need to switch settings groups. Choose from ten time-overcurrent curves.

Figure 23. Schweitzer Engineering Laboratories SEL-487e integrated in exterior cabinet.

Figure 24. Schweitzer Engineering Laboratories SEL-487e integrated in exterior cabinet.

Production elements

- Access security (serial, Ethernet) (ANSI 15 SEC)
- Volts/Hertz (ANSI 24)
- Synchronization check (ANSI 25)
- Undervoltage (ANSI 27)
- Directional power (ANSI 32)
- Current unbalance (ANSI 46)
- Thermal (ANSI 49)
- Breaker failure overcurrent (ANSI 50BF)
- Neutral overcurrent (ANSI 50N)
- Overcurrent (phase, ground, negative sequence) (ANSI 51 P,G,Q)
- Overvoltage (ANSI 59)
- Directional overcurrent (phase, ground negative sequence) (ANSO 67 P,G,Q)
- Over- and under-frequency (ANSI 81 O,U)
- Transformer differential (unrestrained, restrained, negative sequence) (ANSI 87 U,R,Q)
- Event reports (DFR)
- SSEL-2600 (ENV)
- Operator interface (HMI)
- Synchronophasors (PMU)
- Restricted earth fault (REF)
- Remote terminal unit (RTU)
- Sequential events recorder (SER)

Motor operators

VFI switchgear may be specified with motor operators and an associated control to allow for local or remote opening and closing of the switches and vacuum fault interrupters via remote communication. Motor control is available either via advanced relays or with a separate DC motor controller. When using advanced relays such as the Edison Idea, SEL-751, SEL-451, and SEL-487 a full set of communication options are available including ethernet, fiber optic cable, serial ports, and SCADA. Edison Idea and SEL-751 relays can control up to two (2) individual motors on the operating handles. The SEL-451 and Edison iST relays are used for source transfer and control motors on both source ways. The SEL-487e is able to control up to 6 motors. Eaton's stand-alone DC Motor Controller may operate up to six (6) individual motors on the operating handles and communicates via SCADA. Additional motor controllers can be supplied if more than six (6) motors are required. Motor open or close operation occurs 2.5 seconds. This allows for automatic transfer between two (2) sources in 5 seconds. Source transfer requires motors on the sources, six (6) potential transformers and Edison Idea IST relay or SEL-451.

Potential transformers and metering

Advanced protection relays and motor automation require a 120Vac power source. Fluid insulated units typically are provided with internal 1.5 kVA distribution class potential transformers which provide approximately 10% voltage reading accuracy. Supported voltages for internal PTs on WYE (L-G) systems are 2.4 - 19.9 kV and 4.16 - 22.9 kV for Delta (L-L) systems. For metering applications, IEEE metering accuracy PT (0.3 W, X, M, Y/ 1.2Z) and CT (0.3 B-0.5) are able to be supplied up to 35 kV. Extended high accuracy voltage sensing is available with IEEE Instrumentation Metering Accuracy (0.15 B-0.5), PTs are available when even higher accuracy voltage measurements are required. High accuracy PTs and CTs may be paired with a Schweitzer Engineering Laboratories SEL-735 meter from the factory. Elbow voltage sensors with 0.5% accuracy can be paired with the Schweitzer Engineering Laboratories relays to provide additional application versatility. For more information regarding PTs, CTs, voltage sensors and metering, please consult with the factory.

Applicable standards

IEEE Std C37.74™-2003 standard, Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV.

IEEE Std C37.60™-2003 standard, Standard Requirements for Overhead, Pad-Mounted, Dry Vault, and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems Up to 38 kV.

IEEE Std C57.12.28™-2005 standard, Standard for Pad-Mounted Equipment—Enclosure Integrity.

IEEE Std C57.12.29™-2005 standard, Standard for Pad-Mounted Equipment—Enclosure Integrity for Coastal Environments—applicable when stainless steel construction is specified.

IEEE Std 386™-2006 standard, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V.

IEEE Std C37.90™-2005 standard, Standard for Relays and Relay Systems Associated with Electric Power Apparatus.

IEEE Std C37.90.2™-2004 standard, Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.

See page XX for a list of additional information that is available from Eaton.

Specifiers guide

Standard unit configuration:

- Side-hinged (for pad-mounted style) doors
- Three-Phase trip
- Bell Green/Munsell 7GY paint
- Ground Connector in each high voltage compartment

Example:

To specify a VFI unit use the following procedure:

1. Build the descriptor by completing the fields based on the Switchgear requirements:

For example, PMD9E-2N0A is the descriptor for the following standard unit:

- **Pad-mounted, mild steel construction**
- **Double-sided**
- **Model 9 – Two switched source ways and two vacuum fault interrupter protected tap ways**
- **E200 fluid insulation**
- **15 kV, 600 a deadbreak bushings on source ways, 200 a loadbreak bushing wells on tap ways**
- 2-position visible break on all source and tap ways
- **No motor operators**
- **Tri-phase control for the vacuum fault interrupter tap ways** ("EF" TCC curve is the standard that ships Tri-Phase & TPG Control). See Table 22 for other Available TCC Curves)
- Unit is of standard Bell Green/Munsell 7GY paint. If custom color is required, refer to Table 23

2. Identify the options or accessories for inclusion with the standard unit. Refer to Tables 18–32.
3. Submit the descriptor with a list of options and accessories to your Eaton representative for a quotation.

Table 4. Constructing a VFI Switchgear Descriptor

Three-Phase* • 15, 25 and 35 kV Nominal

200 and 600** A Max Continuous • 12500‡ A Interrupting Rating

Pad-Mounted • Electronically Controlled • Vacuum Fault Interrupters • Deadfront Construction

PM **Unit Style** – Refer to Table 5
D **Unit Configuration** – Table 6
9 **Model Number** – Table 13–17
E **Insulating Medium** – Table 7
2 **Voltage & Bushing Ratings** – Table 8
D **Visible Break** – Table 9
0 **Motor Operators** – Table 10
A **Controls** – Table 11–12

PM D 9 E 2 E 0 A is the required descriptor†

Table 5. Unit Style

Pad-Mounted style, Mild Steel	PM
Pad-Mounted style, Stainless Steel 304L	PS
Vault-Mounted style (no cabinets), Mild Steel	VM
Vault-Mounted style (no cabinets), Stainless Steel 304L	VS

Table 6. Unit Configuration

Double-Sided	A
Single-Sided	B
Compact, Single-Sided	C
Split 2-Sided, Bushings Opposite Side From Handles	D

Table 7. Insulating Medium

Mineral Oil	O
Envirotemp TM FR3 Fluid	F
E200 Fluid	E
SF6 Gas Insulation	S

Table 8. Voltage & Bushing Rating

Voltage	600A/600A	600A/200A	200A/200A
15 kV	1	2	3
25 kV	4	5	6
35 kV	7	8	9

Table 9. Visible Break

	All Ways	All Source	All Tap
None (Select For SF6)	N	–	–
2 Position (Open/Close)	A	B	C
3 Position (Open/Close/Ground)	D	E	F

Table 10. Motor Operators

	All Ways	All Source	All Tap
None	0	–	–
Provisions Future Motors	1	2	3
Motors Installed	4	5	6

Table 11. CT Powered Controls

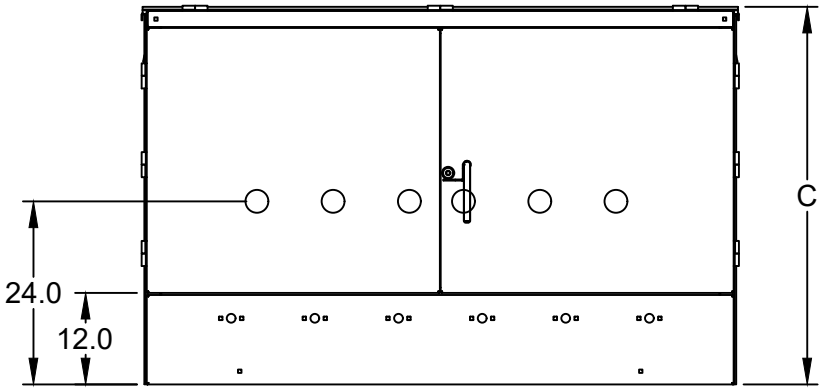
CT Control Options	
Tri-Phase	A
Tri-Phase W/ Ground	B
Tri-Phase W/ Ground & SCADA	C

Table 12. Advanced Relay Controls

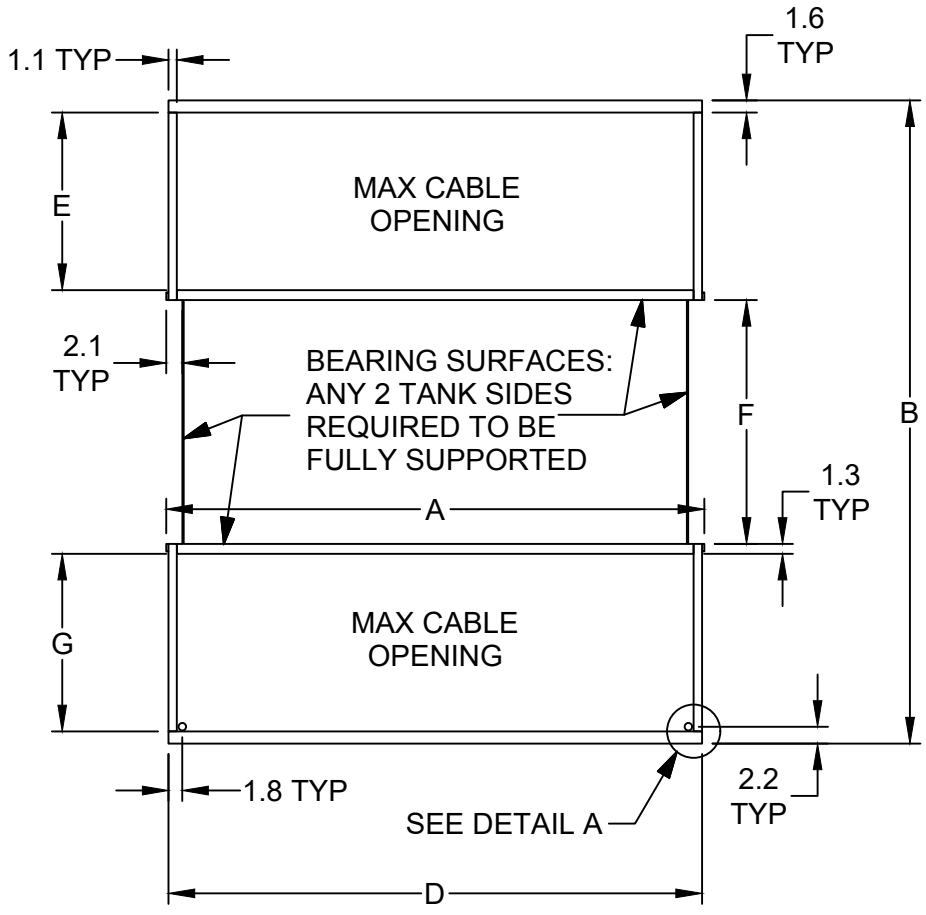
Eaton iDEA Relay	D
SEL Relay	E

* Single-Phase units available. Consult Factory.
** For 900 and 1200 A continuous rating. Consult Factory.
† For 16000 A (15 kV) interrupting rating. Consult Factory.
‡ The descriptor is not the catalog number, but a shorthand method of describing the unit.

Dimensions



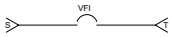
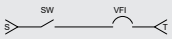
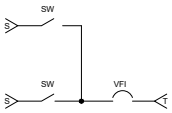
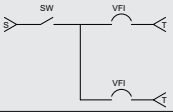
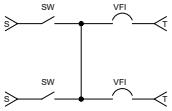
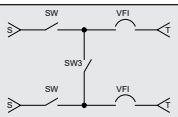
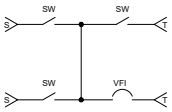
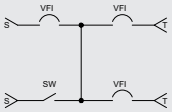
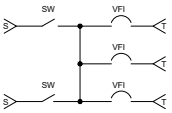
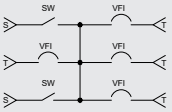
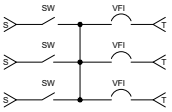
(FRONT VIEW)



BASE DIMENSIONS

Figure 25. Double-sided VFI switchgear (without visible-break switch)

Table 13. Double-Sided VFI Switchgear without visible break switch (see figure 25 above) (All dimensions shown in inches)†

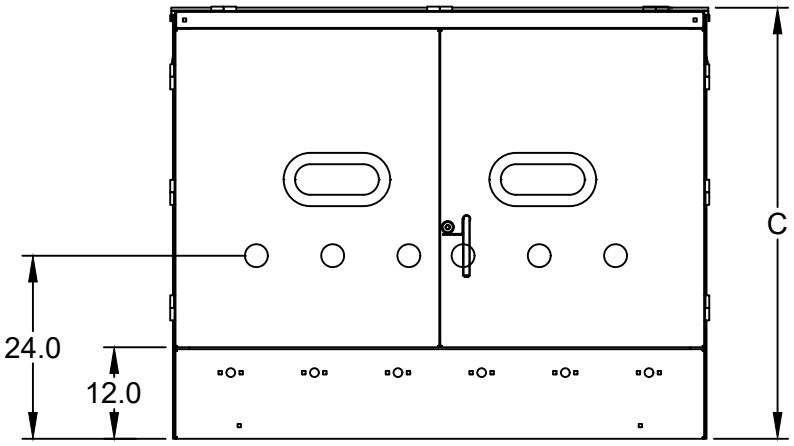
Model*	One-Line Diagram**	Nominal Voltage (kV)	A	B	C	D	E	F	G	WEIGHT IN LBS.	FLUID IN GAL.
5		15	40.50	72.40	49.50	40.00	22.00	28.00	22.00	1600	68
		25	40.50	72.40	49.50	40.00	22.00	28.00	22.00	1600	68
		35	40.50	80.40	49.50	40.00	26.00	28.00	26.00	1600	68
2W1		15	40.50	72.40	49.50	40.00	22.00	32.00	22.00	1800	90
		25	40.50	72.40	49.50	40.00	22.00	32.00	22.00	1800	90
		35	40.50	80.40	49.50	40.00	26.00	32.00	26.00	1800	90
6		15	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3100	165
		25	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3100	165
		35	70.50	76.40	49.50	70.00	22.00	35.00	26.00	3100	191
7		15	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3100	165
		25	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3100	165
		35	70.50	76.40	49.50	70.00	22.00	35.00	26.00	3100	191
9		15	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3100	165
		25	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3100	165
		35	70.50	76.40	49.50	70.00	22.00	35.00	26.00	3100	191
9T		15	84.50	79.40	49.50	84.00	22.00	35.00	22.00	4400	292
		25	84.50	79.40	49.50	84.00	22.00	35.00	22.00	4400	292
		35	84.50	89.40	49.50	84.00	26.00	37.00	26.00	4800	309
11		15	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3200	165
		25	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3200	165
		35	70.50	87.40	49.50	70.00	26.00	35.00	26.00	3500	191
12		15	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3200	165
		25	70.50	76.40	49.50	70.00	22.00	32.00	22.00	3200	165
		35	70.50	87.40	49.50	70.00	26.00	35.00	26.00	3500	191
5W2		15	84.50	79.40	49.50	84.00	22.00	35.00	22.00	4200	219
		25	84.50	79.40	49.50	84.00	22.00	35.00	22.00	4200	219
		35	104.50	89.40	49.50	104.00	26.00	37.00	26.00	4900	290
6W2		15	84.50	79.40	49.50	84.00	22.00	37.00	22.00	4400	231
		25	84.50	79.40	49.50	84.00	22.00	37.00	22.00	4400	231
		35	104.50	91.40	49.50	104.00	26.00	39.00	26.00	5200	305
6W3		15	84.50	81.40	49.50	84.00	22.00	37.00	22.00	4400	231
		25	84.50	81.40	49.50	84.00	22.00	37.00	22.00	4400	231
		35	104.50	91.40	49.50	104.00	26.00	39.00	26.00	5200	305

* Other models are available. Consult Factory.

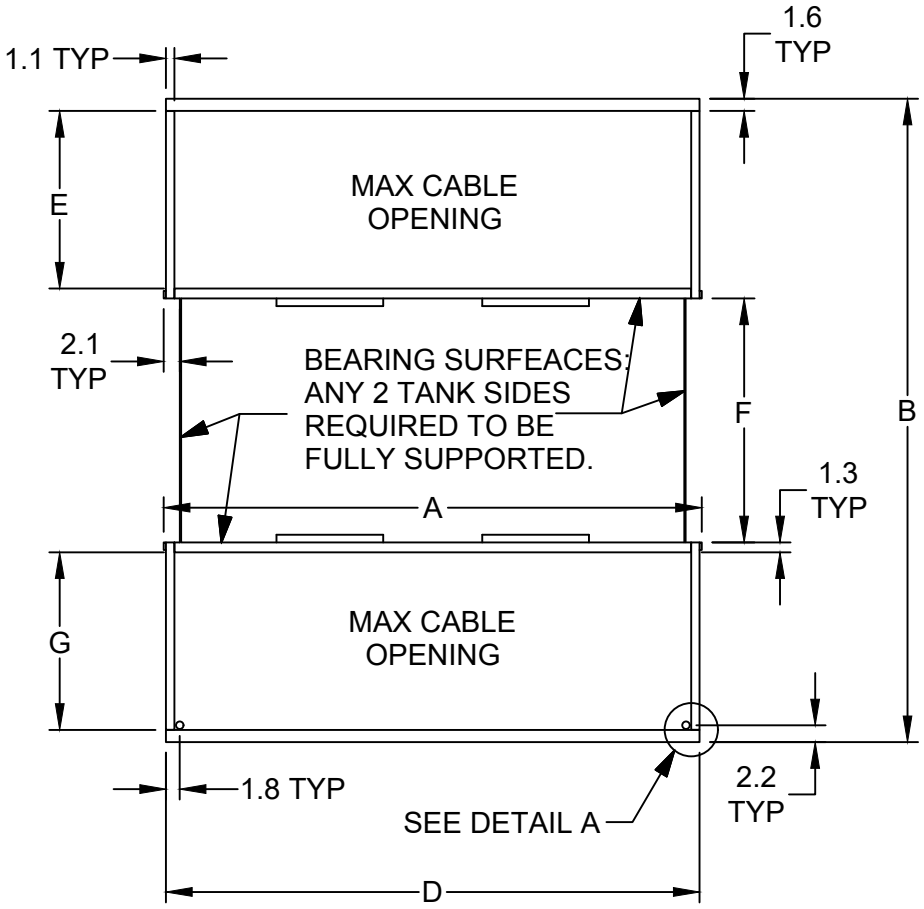
** One-Line Diagram depicts the standard physical arrangement. Standard "source" and "tap" designation indicated by "S" and "T" on one-line diagrams.

† Dimensions are per standard configurations with CT powered controls and no additional accessories (relay controls, motor operators, potential transformers). For details regarding these, consult factory

Dimensions



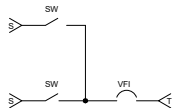
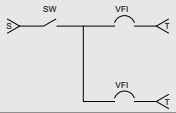
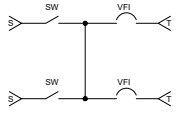
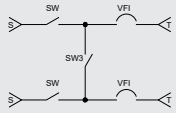
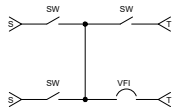
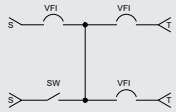
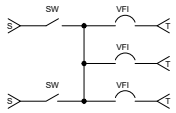
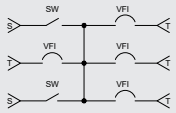
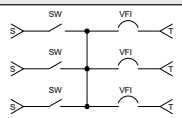
(FRONT VIEW)



BASE DIMENSIONS

Figure 26. Double-sided VFI switchgear (with visible-break switch)

Table 14. Double-Sided VFI Switchgear With Visible-Break Switch on Source Ways only† (see figure 26 above) (All dimensions shown in inches)‡

Model*	One-Line Diagram**	Nominal Voltage (kV)	A	B	C	D	E	F	G	WEIGHT IN LBS.	FLUID IN GAL.
5		15	40.50	76.40	56.50	40.00	22.00	32.00	22.00	2000	100
		25	40.50	76.40	56.50	40.00	22.00	32.00	22.00	2000	100
		35	40.50	84.40	56.50	40.00	26.00	32.00	26.00	2000	100
2W1		15	40.50	81.40	56.50	40.00	22.00	37.00	22.00	2200	120
		25	40.50	81.40	56.50	40.00	22.00	37.00	22.00	2200	120
		35	40.50	89.40	56.50	40.00	26.00	37.00	26.00	2200	120
6		15	70.50	81.40	56.50	70.00	22.00	37.00	22.00	3500	215
		25	70.50	81.40	56.50	70.00	22.00	37.00	22.00	3500	215
		35	70.50	91.40	56.50	70.00	26.00	39.00	26.00	3700	225
7		15	70.50	81.40	56.50	70.00	22.00	37.00	22.00	3500	215
		25	70.50	81.40	56.50	70.00	22.00	37.00	22.00	3500	215
		35	70.50	91.40	56.50	70.00	26.00	39.00	26.00	3700	225
9		15	70.50	81.40	56.50	70.00	22.00	37.00	22.00	3500	215
		25	70.50	81.40	56.50	70.00	22.00	37.00	22.00	3500	215
		35	70.50	91.40	56.50	70.00	26.00	39.00	26.00	3700	225
9T		15	70.50	83.40	56.50	84.00	22.00	3900	22.00	5000	335
		25	70.50	83.40	56.50	84.00	22.00	3900	22.00	5000	335
		35	70.50	95.40	56.50	84.00	26.00	4300	26.00	5300	370
11		15	70.50	87.40	56.50	70.00	22.00	43.00	22.00	3500	250
		25	70.50	87.40	56.50	70.00	22.00	43.00	22.00	3500	250
		35	70.50	95.40	56.50	70.00	26.00	43.00	26.00	3600	250
12		15	91.40	76.40	56.50	70.00	22.00	46.00	22.00	3500	265
		25	91.40	76.40	56.50	70.00	22.00	46.00	22.00	3500	265
		35	98.40	87.40	56.50	70.00	26.00	46.00	26.00	3600	265
5W2		15	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6500	405
		25	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6500	405
		35	104.50	98.40	56.50	104.00	26.00	46.00	26.00	6600	405
6W2		15	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6600	405
		25	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6600	405
		35	104.50	90.40	56.50	104.00	26.00	46.00	26.00	6700	405
6W3		15	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6600	405
		25	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6600	405
		35	104.50	98.40	56.50	104.00	26.00	46.00	26.00	6700	405

* Other models are available. Consult Factory.

** One-Line Diagram depicts the standard physical arrangement. Standard "source" and "tap" designation indicated by "S" and "T" on one-line diagrams.

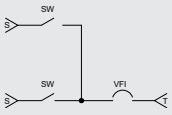
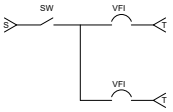
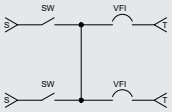
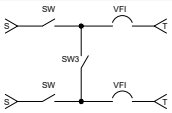
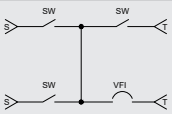
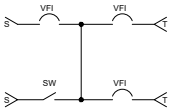
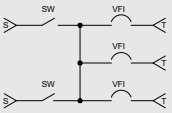
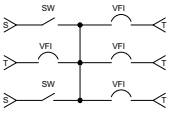
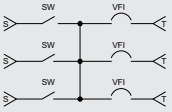
† VFI mechanism and visible break switch are located on tap way for Model 5.

‡ Dimensions are per standard configurations with CT powered controls and no additional accessories (relay controls, motor operators, potential transformers).

For details regarding these, consult your Eaton representative.

NOTE: This table provides standard product dimensional information only. Dimensions are NOT for construction purposes. Foundation construction should comply with local building or construction codes as required. If needed, request engineering drawings for approval or drawings for record purposes with your order.

Table 15. Double-Sided VFI Switchgear With Visible-Break Switch on all ways (see figure 22 above) (All dimensions shown in inches)‡

Model*	One-Line Diagram**	Nominal Voltage (kV)	A	B	C	D	E	F	G	WEIGHT IN LBS.	FLUID IN GAL.
2W1		15	40.50	87.40	56.50	40.00	22.00	43.00	22.00	2200	120
		25	40.50	87.40	56.50	40.00	22.00	43.00	22.00	2200	120
		35	40.50	95.40	56.50	40.00	26.00	43.00	26.00	2200	120
6		15	70.50	87.40	56.50	70.00	22.00	43.00	22.00	3500	250
		25	70.50	87.40	56.50	70.00	22.00	43.00	22.00	3500	250
		35	70.50	95.40	56.50	70.00	26.00	43.00	26.00	3800	250
7		15	70.50	87.40	56.50	70.00	22.00	43.00	22.00	3500	250
		25	70.50	87.40	56.50	70.00	22.00	43.00	22.00	3500	250
		35	70.50	95.40	56.50	70.00	26.00	43.00	26.00	3800	250
9		15	70.50	87.40	56.50	70.00	22.00	43.00	22.00	4100	250
		25	70.50	87.40	56.50	70.00	22.00	43.00	22.00	4100	250
		35	70.50	95.40	56.50	70.00	26.00	43.00	26.00	4200	250
9T		15	84.50	90.40	56.50	84.00	22.00	4600	22.00	5000	335
		25	84.50	90.40	56.50	84.00	22.00	4600	22.00	5000	335
		35	84.50	98.40	56.50	84.00	26.00	4600	26.00	5300	370
11		15	70.50	90.40	56.50	70.00	22.00	4300	22.00	3500	250
		25	70.50	90.40	56.50	70.00	22.00	4300	22.00	3500	250
		35	70.50	95.40	56.50	70.00	26.00	4300	26.00	3800	250
12		15	70.50	90.40	56.50	70.00	22.00	46.00	22.00	4300	265
		25	70.50	90.40	56.50	70.00	22.00	46.00	22.00	4300	265
		35	70.50	95.40	56.50	70.00	26.00	46.00	26.00	4400	265
5W2		15	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6900	405
		25	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6900	405
		35	104.50	98.40	56.50	104.00	26.00	46.00	26.00	6900	405
6W2		15	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6900	405
		25	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6900	405
		35	104.50	98.40	56.50	104.00	26.00	46.00	26.00	7000	405
6W3		15	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6900	405
		25	104.50	90.40	56.50	104.00	22.00	46.00	22.00	6900	405
		35	104.50	98.40	56.50	104.00	26.00	46.00	26.00	7000	405

* Other models are available. Consult Factory.

** One-Line Diagram depicts the standard physical arrangement. Standard "source" and "tap" designation indicated by "S" and "T" on one-line diagrams.

† VFI mechanism and visible break switch are located on tap way for Model 5.

‡ Dimensions are per standard configurations with CT powered controls and no additional accessories (relay controls, motor operators, potential transformers). For details regarding these, consult your Eaton representative.

NOTE: This table provides standard product dimensional information only. Dimensions are NOT for construction purposes. Foundation construction should comply with local building or construction codes as required. If needed, request engineering drawings for approval or drawings for record purposes with your order.

Dimensions

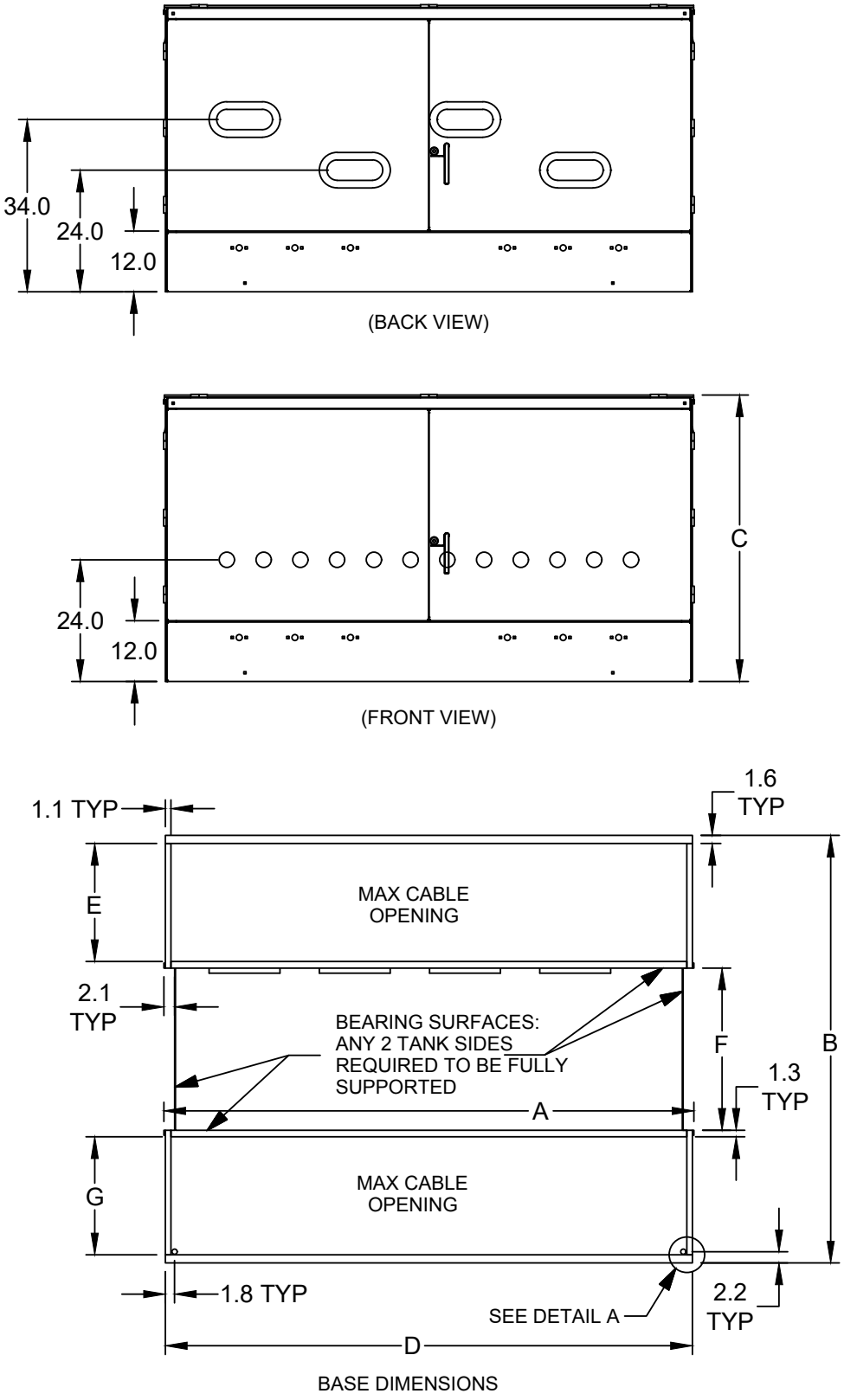
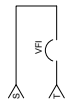
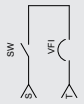
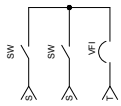
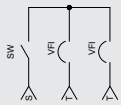
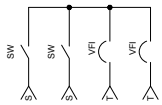
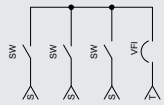
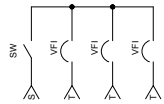


Figure 27. Split 2-sided VFI switchgear

**Table 16. Split 2-Sided VFI Switchgear with or without visible break †
(see figure 27 above)
(All dimensions shown in inches)‡**

Model*	One-Line Diagram**	Nominal Voltage (kV)	A	B	C	D	E	F	G	WEIGHT IN LBS.	FLUID IN GAL.
5		15	70.50	76.40	56.50	70.00	22.00	43.00	32.00	3200	195
		25	70.50	76.40	56.50	70.00	22.00	43.00	32.00	3200	195
		35	70.50	80.40	56.50	70.00	26.00	43.00	32.00	3300	195
2W1		15	70.50	76.40	56.50	70.00	22.00	43.00	32.00	3200	195
		25	70.50	76.40	56.50	70.00	22.00	43.00	32.00	3200	195
		35	70.50	80.40	56.50	70.00	26.00	43.00	32.00	3300	195
6		15	84.50	76.40	56.50	84.00	22.00	43.00	32.00	4800	315
		25	84.50	76.40	56.50	84.00	22.00	43.00	32.00	4800	315
		35	84.50	80.40	56.50	84.00	26.00	43.00	32.00	4900	315
7		15	84.50	76.40	56.50	84.00	22.00	43.00	32.00	4800	315
		25	84.50	76.40	56.50	84.00	22.00	43.00	32.00	4800	315
		35	84.50	80.40	56.50	84.00	26.00	43.00	32.00	4900	315
9		15	104.50	76.40	56.50	104.00	22.00	4600	32.00	6400	480
		25	104.50	76.40	56.50	104.00	22.00	4600	32.00	6400	480
		35	104.50	80.40	56.50	104.00	26.00	4600	32.00	6500	480
11		15	104.50	76.40	56.50	104.00	22.00	4300	32.00	6400	480
		25	104.50	76.40	56.50	104.00	22.00	4300	32.00	6400	480
		35	104.50	80.40	56.50	104.00	26.00	4300	32.00	6500	480
12		15	104.50	76.40	56.50	104.00	22.00	46.00	32.00	6400	480
		25	104.50	76.40	56.50	104.00	22.00	46.00	32.00	6400	480
		35	104.50	80.40	56.50	104.00	26.00	46.00	32.00	6500	480

* Other models are available. Consult Factory.

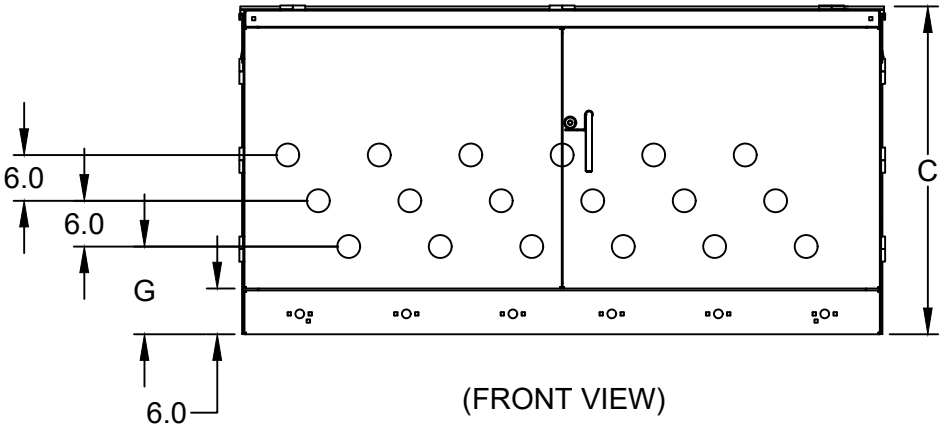
** One-Line Diagram depicts the standard physical arrangement. Standard "source" and "tap" designation indicated by "S" and "T" on one-line diagrams.

† VFI mechanism and visible break switch are located on tap way for Model 5.

‡ Dimensions are per standard configurations with CT powered controls and no additional accessories (relay controls, motor operators, potential transformers). For details regarding these, consult your Eaton representative.

NOTE: This table provides standard product dimensional information only. Dimensions are NOT for construction purposes. Foundation construction should comply with local building or construction codes as required. If needed, request engineering drawings for approval or drawings for record purposes with your order.

Dimensions



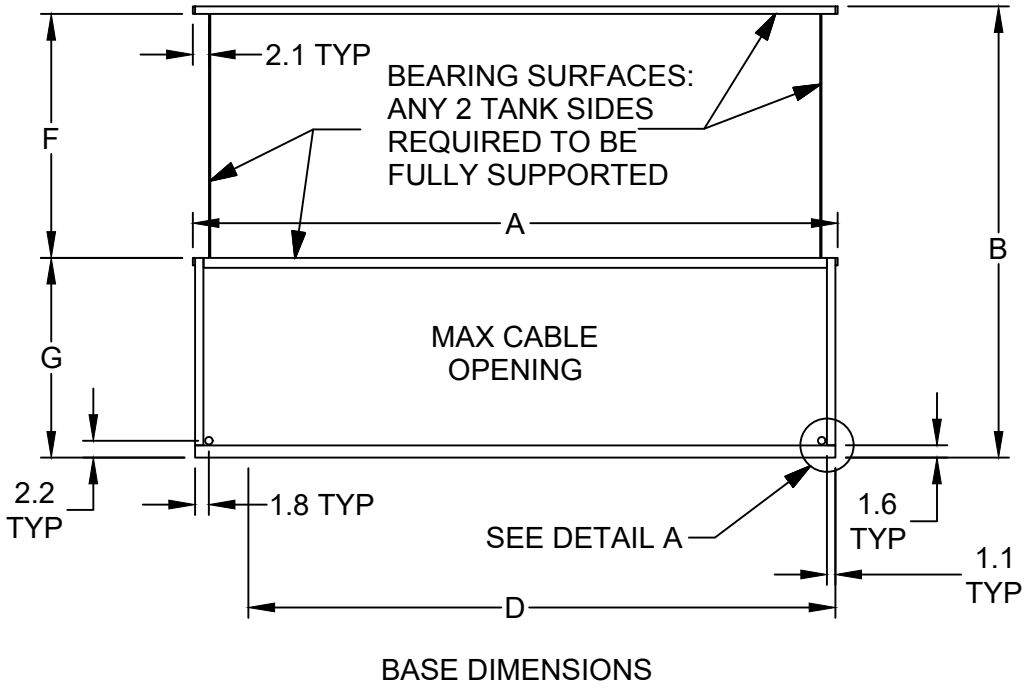
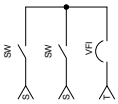
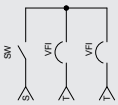
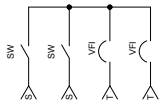
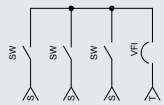
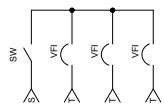
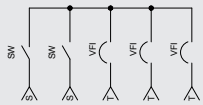
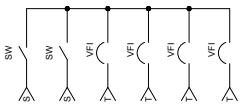
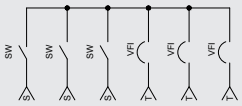


Figure 28. Single-sided, compact-style VFI switchgear

Table 17. Single-Sided, Compact-Style VFI Switchgear (see figure 28 above) (All dimensions shown in inches)‡

Model*	One-Line Diagram**	Nominal Voltage (kV)	A	B	C	D	E	F	G	WEIGHT IN LBS.	FLUID IN GAL.
6		15	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		25	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		35	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
7		15	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		25	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		35	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
9		15	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		25	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		35	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
11		15	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		25	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		35	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
12		15	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		25	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
		35	62.50	62.30	43.50	62.30	30.00	30.00	11.50	2400	165
5W2		15	74.50	62.30	43.50	74.50	30.00	30.00	11.50	3100	195
		25	74.50	62.30	43.50	74.50	30.00	30.00	11.50	3100	195
		35	74.50	62.30	43.50	74.50	30.00	30.00	11.50	3100	195
6W2		15	84.50	62.30	43.50	74.50	30.00	30.00	11.50	3800	225
		25	84.50	62.30	43.50	74.50	30.00	30.00	11.50	3800	225
		35	84.50	62.30	43.50	74.50	30.00	30.00	11.50	3800	225
6W3		15	84.50	62.30	43.50	74.50	30.00	30.00	11.50	3800	225
		25	84.50	62.30	43.50	74.50	30.00	30.00	11.50	3800	225
		35	84.50	62.30	43.50	74.50	30.00	30.00	11.50	3800	225

* Other models are available. Consult Factory.

** One-Line Diagram depicts the standard physical arrangement. Standard "source" and "tap" designation indicated by "S" and "T" on one-line diagrams.

† Dimensions are per standard configurations with CT powered controls and no additional accessories (relay controls, motor operators, potential transformers). For details regarding these, consult your Eaton representative.

NOTE: This table provides standard product dimensional information only. Dimensions are NOT for construction purposes. Foundation construction should comply with local building or construction codes as required. If needed, request engineering drawings for approval or drawings for record purposes with your order.

Optional features

Table 18. Vacuum Fault Interrupter Operation

Type	Description	Location
Vacuum Fault Interrupter Type (select one)*	Three-Phase Ganged Trip **(STANDARD)**	All Fault Interrupters
	Single-Phase Trip	All Fault Interrupters
	Mixture of Single-Phase and Three-Phase Trip	Specify location for each type

* All mechanisms are front mount front operated, side operation is available for Three-Phase gang trip ways, consult factory

Table 19. Visible-Break Switch* Options

Description	Visible-Break Positions
No Visible-Break **(STANDARD)** Two-position	N/A
Visible-Break—close-open Three-position	All Source Ways All Tap Ways All Source and Tap ways
Visible-Break—close-open-ground	
CleerTM- External Visible-Break -Close-open**	

* Visible-Break Switch available only for double-sided, fluid-filled switchgear.

** Cleer External loadbreak available for 3ph ganged and 1-phase ways up to 25kv for.

Table 20. Bushing Options

Current Rating	Description
200 A Ways (select only one)	Bushing wells (copper studs) **(STANDARD)**
	Bushing wells (copper studs) with loadbreak inserts**
	Single-piece large interface, integral, loadbreak bushings*
600 A Ways (select only one)	600 A deadbreak bushings **(STANDARD)**
	PUSH-OP™ bushings
	U-OP™ systems with aluminum Visible-Break Junctions & U-connectors**
	U-OP provisions**
600 A & 200 A	Externally Replaceable Bushing/Wells (on all ways)†
900 A** & 1200 A***	Single-piece deadbreak bushings (copper)

Note: Aluminum is standard for bushing material.

* Only for 35 kV units, large interface design.

** Only for 15, 25 kV unit.

*** Only for 15 kV unit.

† Excludes compact style units. Standard on SF6 units.

Table 21. Controls*

Control Type	Overcurrent	Ground	Metering	SCADA	Comms	Advanced Functions
Tri-Phase control **(STANDARD)**‡	X					
TPG control (Tri-Phase control with ground)‡	X	X				
TPG with SCADA‡	X	X		X		
Edison Idea iTAP-265 relay (Three-Phase Trip)	X	X	X**	X	X	
Edison Idea iTAP-260 relay (Single-Phase Trip)	X	X	X**	X	X	
Edison Idea iDP-210 relay	X	X	X**	X	X	X**
Edison Idea IST-621 relay (Source Transfer)	X	X	X**	X	X	X**
SEL-501 relay	X	X		X	X	
SEL-751 relay	X	X	X**	X	X	X**
SEL-451 relay	X	X	X	X	X	X
SEL-487e relay	X	X	X	X	X	X

* Consult factory for automation options using advanced controllers and communications.

** For metering and advanced functions requiring potential transformers in SF6 insulated switchgear, contact your Eaton representative.

‡ Select the TCC curve and the optional Minimum Response Time curve from Table 22.

Table 22. Tri-Phase/TPG Control Options

Time-Current Curve Card (TCC) (select only one)	EF Curve **(STANDARD)**
	KF Curve
	TF Curve
	H Curve
	F Curve
Minimum Response Timing Accessory (select only one)	EFR Curve **(STANDARD)**
	KFR Curve
	TFR Curve
	HR Curve
	FR Curve
Ground Trip Block Switch	for TPG only
CT Shorting Switch	for TPG only

Table 23. Construction

Tank Style	Material	Construction
Vault-Mounted Style*	Tank Material	Mild Steel construction with non-corrosive hardware **(STANDARD)**
		304L Stainless steel construction
Pad-Mounted Style	Tank/Cabinet Material	Mild Steel construction with non-corrosive hardware **(STANDARD)**
		304L Stainless steel construction
Paint color	Bell Green/Munsell 7GY **(STANDARD)**	
	Other paint color, top coat on external surfaces only (specify the Federal Spec Paint number)	

* Change first two digits of descriptor from Table 5 from "PM" to "PV" as shown on page 8.

Table 24. Distribution Automation

Description	Motor Operator Positions
No motor operators/provisions **(STANDARD)**	N/A
Motor operator provisions	Specify the ways: Source, Tap or All
Motor operators (compare with Table 10)*	
Options for Discrete Motor Controller**	
Remote Pendent	25-200 FT Cable length, 25 FT Increments

* Motor operators and Motor Provisions include semaphores as standard

** Used to control motors via SCADA on units which do not utilize advanced relays.

Table 25. Customer Auxiliary Switch

Type	Position
Two-Stage Auxiliary Switch (Qty 2: 52A, 52B)	Specify the ways: Source, Tap or All
Options*	
Auxiliary Switch wired to Terminal Block on Junction Box	
Plug Body	

* Cable not included.

Table 26. Indicators

Description	Indicator Positions
Operation counter	Specify the ways: Source, Tap or All
Semaphore*	Specify the ways: Source, Tap or All

* Position indicator linked directly to operating mechanism and viewable through tank window.

Table 27. Grounding Options (select only one)

Ground Stud **(STANDARD)**
1/2" Round copper ground-bus
3" stand-off bracket for 1/2" round bus
NEMA® Ground Pad stainless steel (welded to tank)
1/4" X 1.5" Flat copper ground-bus with 5/8" holes

Table 28. Fault Indicator Provisions (select only one)
(With removable stainless steel backplate)

No Fault Indicator provisions **(STANDARD)**
Provisions for Fault Circuit Indicators (FCI) (1.06" dia. hole)*
Provisions for S.T.A.R.™ FCI with large FISHEYE™ 1.75" dia. hole
Provisions for S.T.A.R. FCI with small remote 1.0" dia hole
Provisions for LED Display Indicator .313" dia hole

* Accommodates future installation of S.T.A.R. FCI type indicators

Table 29. Service and Miscellaneous Items

Description	
1" drain plus with 3/8" sampler **(STANDARD)***	Select only one
1" drain valve with 3/8" sampler*	
1" external drain valve with 3/8" sampler on tank with lockable cover*	
Penta-head door bolt **(STANDARD)**	Select only one
Hex-head door bolt	
3" Stainless Steel Base Riser	

* Not applicable to SF_6 units.

Table 30. Service Items-Accessories

Description	Kit Number
SF_6 refill kit; hoses, valves, regulator	KPA-1043-1
SF_6 refill kit; hoses and valves (without regulator)	KPA-1043-1
Bracket to convert single-phase trip unit into three-phase unit	Consult Factory
Hotstick tool for three-phase trip unit into three-phase trip unit	KPA-111
Yellow manual handle for Switch & VFI ways for Kirk Key	KP-29759-4S

* Prices listed are for all Models.

Table 31. Key Interlocks

Description
Provisions for key interlocks
Key interlocks to prevent paralleling of source 1 and source 2 *
Key interlock provisions for Ground position on visible break

* End user name and address required at time of order to provide this feature

Table 32. Decals

Danger High Voltage	Specify Location
Internal Mr. Ouch, bilingual	
External Mr. Ouch, bilingual	
Non PCB	

Additional information

CA165002EN, iDP-210 Feeder Protection Relay

CA165005EN, iTAP-265 Dual Overcurrent Relay

MN285006EN, VFI Oil-Insulated Installation Instructions

MN285004EN, VFI SF_6-Insulated, Vacuum Fault Interrupter; installation, Operation and Maintenance Instructions

MN285010EN, SF_6 Gas Top-Off Kit Operation Instructions

MN285011EN, Visible Break Switch Accessory Operation Instructions

MN285012EN, VFI Fault Interrupter w/Tri-Phase Control Single-Phase Trip to Three-Phase Trip Conversion Kit Instructions

MN285001EN, VFI Tester Operation Instructions

MN285058EN, Tri-Phase, TPG, and TPG with SCADA Electronic Control Installation and Operation Instructions

PA165001EN, iDP-210 Feeder Protection Relay Bulletin

PA285003EN, VFI Underground Distribution Switchgear - Environmentally Preferred Switchgear

TD285003EN, Guide for Atmospheric Retrofilling of 38 kV (or lower) Fluid-filled Switchgear

PA285005EN, Smart VFI for Solar Applications

PA285002EN, Smart VFI Underground Distribution Switchgear

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